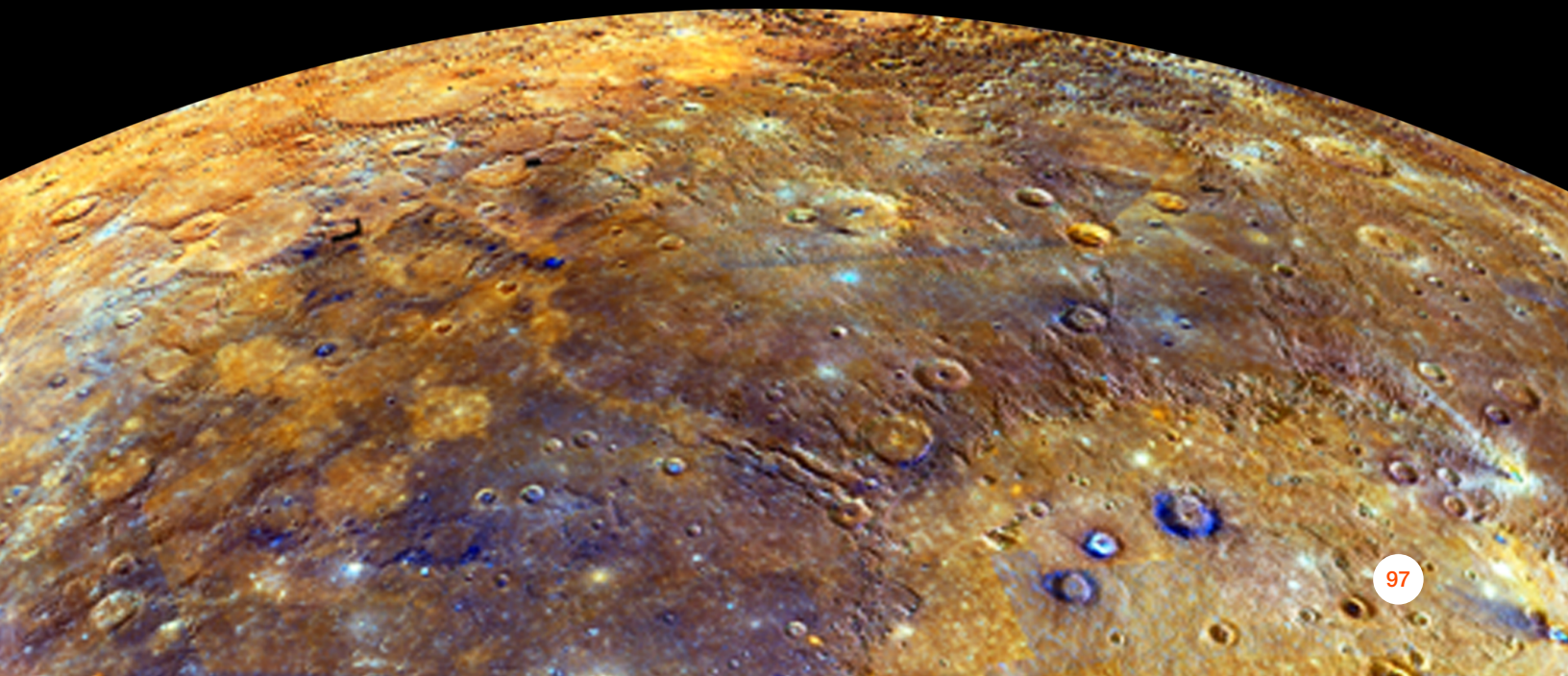
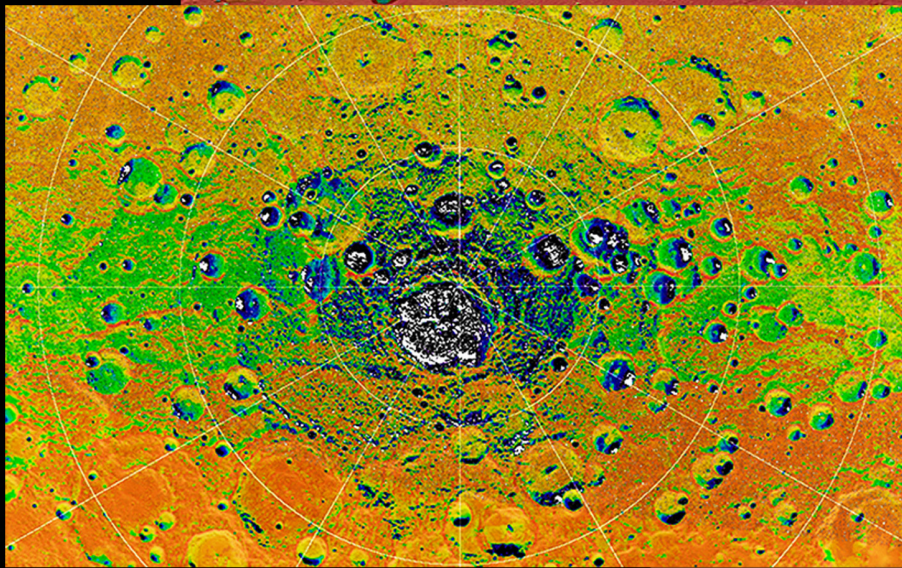
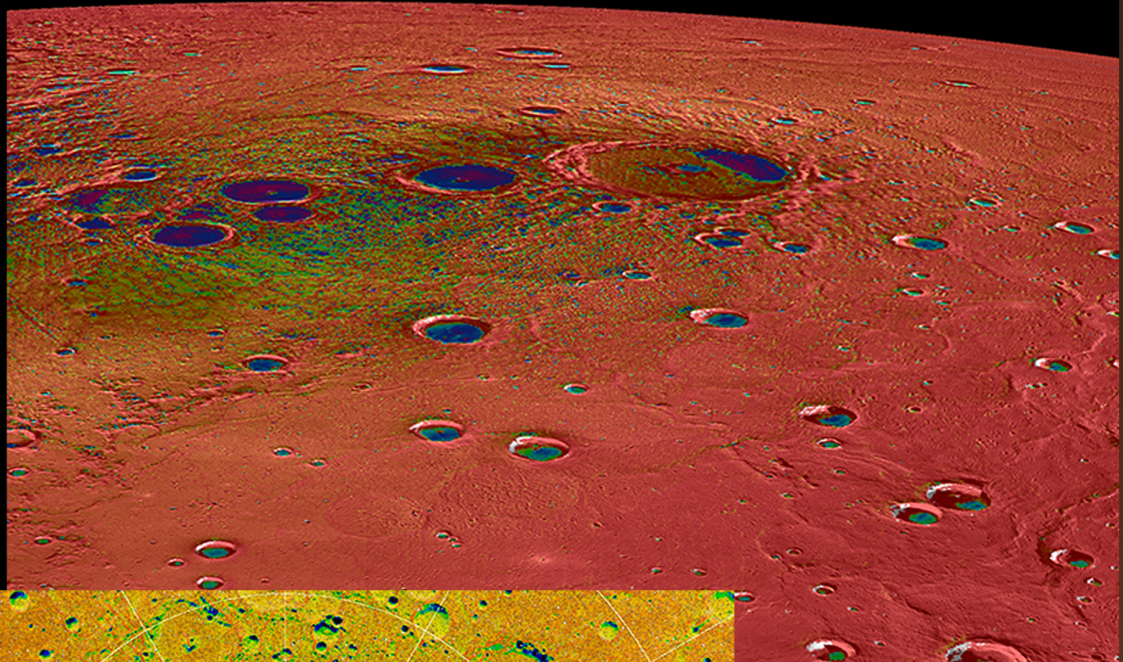


MESSENGER
**SCIENCE RESULTS
AND
TEAM HIGHLIGHTS**



Surface Temperature

Mercury's north-polar region, colored by maximum calculated surface temperature, which ranges from >400 degrees Kelvin (K) (red) to 50 K (purple). *(Image credit: NASA/APL/CIW)*

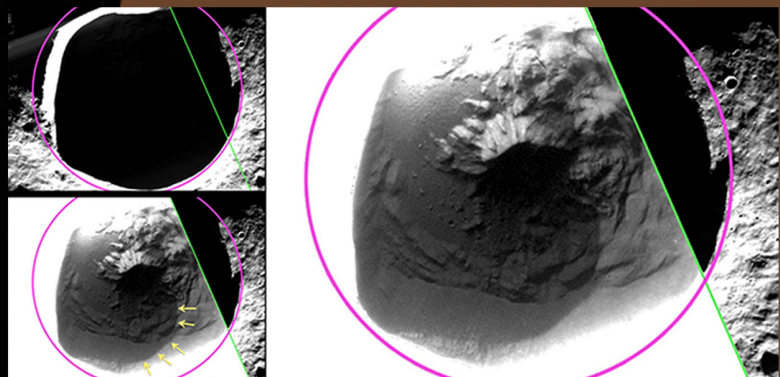


Surface Illumination

Mercury's south-polar region, colored by solar illumination over a solar day. Regions in black never receive direct sunlight, enabling water ice to survive in these cold locations. The regions in white are data from Earth-based radar observations that indicate the likely presence of water ice. *(Image credit: NASA/APL/CIW)*

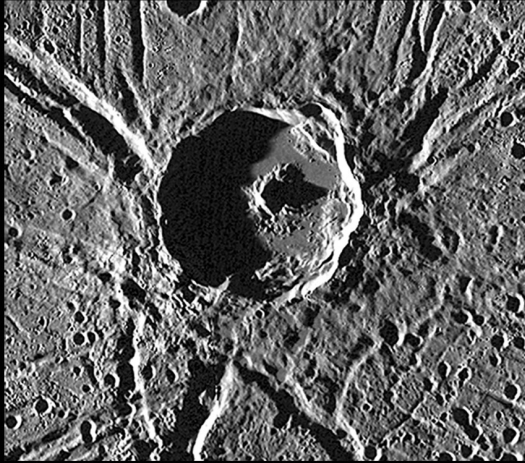
Looking into Permanent Shadows

Imaging by the Mercury Dual Imaging System (MDIS) instrument in a permanently shadowed crater reveals water ice in areas of lower temperatures in the shadows inside the craters. *(Image credit: NASA/APL/CIW)*



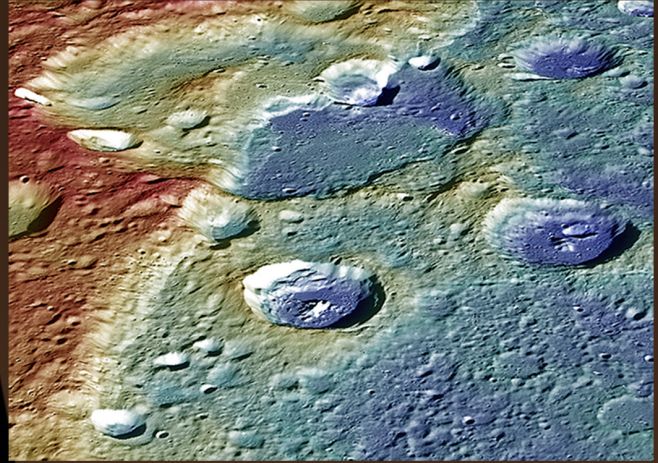
Water Ice on Mercury

Thermal analysis, together with elemental abundance measurements from the Gamma-Ray and Neutron Spectrometer (GRNS) instrument, images from the Mercury Dual Imaging System (MDIS), and reflectance measurements from the Mercury Laser Altimeter (MLA), address the questions that remained regarding the presence and distribution of water ice within permanently shadowed parts of Mercury's polar regions.



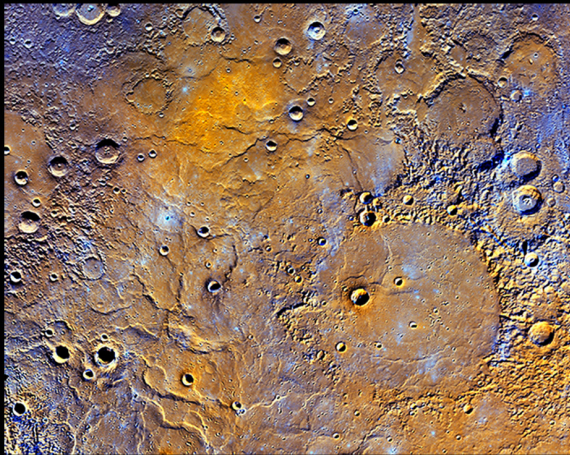
Impact Craters

One of the most captivating views acquired by the MDIS instrument during MESSENGER's first Mercury flyby was the crater Apollodorus surrounded by the radiating troughs of Pantheon Fossae. *(Image credit: NASA/APL/CIW)*



Tectonic Features

A perspective view of part of Carnegie Rupes, a large tectonic landform, showing the terrain as measured by the Mercury Laser Altimeter (MLA) instrument, color-coded to highlight the variations in topography (red = high-standing; blue = low-lying). The colors were overlaid on a mosaic created from 48 individual MDIS images. Such tectonic features form on Mercury as a response to interior planetary cooling, resulting in the overall shrinking of the planet. *(Image credit: NASA/APL/CIW)*

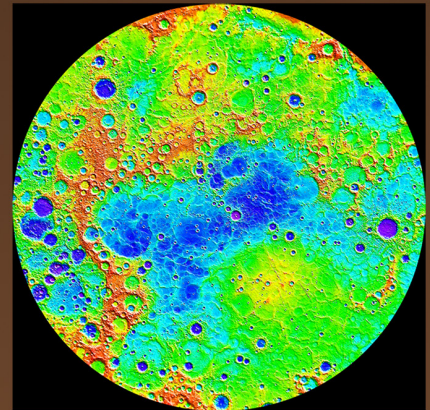


Volcanic Plains

Ancient volcanism buried large portions of Mercury's surface beneath lavas >1 mile deep in areas, such as Mercury's northern smooth plains, in orange in this MDIS image color enhanced to emphasize different rock types. *(Image credit: NASA/APL/CIW)*

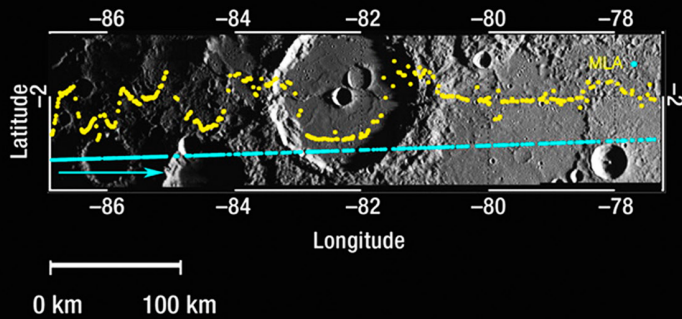
Northern Topography

Measurements from MESSENGER's MLA instrument during the spacecraft's >4-Earth-year orbital mission mapped the topography of Mercury's northern hemisphere in great detail. This interpolated shaded relief map of these data shows the lowest regions in purple and the highest regions in red. The difference in elevation is ~10 km. *(Image credit: NASA/APL/CIW)*



Hollows

This image, acquired by the MDIS instrument, shows the incredibly smooth floor of these small hollows located within the Shoem Aleichem basin. No impact craters are visible on the floor of the hollows, even though many small craters are evident on the surroundings, suggesting that the hollows are very young compared with most of Mercury's surface. One of the highest-quality and highest-resolution images of hollows, this image was serendipitously collected as a "ride-along" image, when another one of MESSENGER's science instruments was controlling where the spacecraft pointed. *(Image credit: NASA/APL/CIW)*

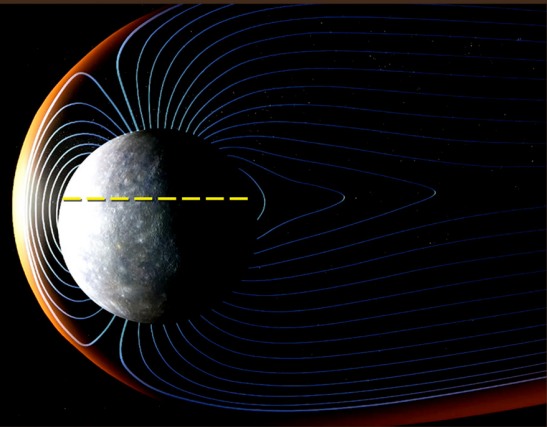


Altimetry

This image shows a 400-km (250-mile) section of the MLA profile from MESSENGER's second Mercury flyby superimposed on a high-resolution MDIS mosaic acquired during the same encounter. The blue dots indicate the spacecraft's ground track, and the yellow dots show the altimetry data points; the blue arrow shows the spacecraft's direction of travel. (Image credit: NASA GSFC/APL/CIW)

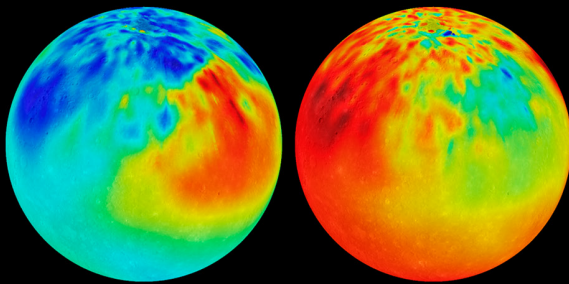
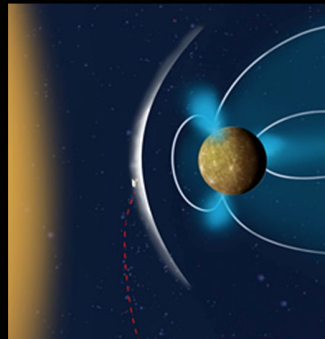
Planetary Magnetism

Observations by MESSENGER's Magnetometer (MAG) showed that Mercury's magnetic field is offset along the planetary spin axis by about 20% of the planet's radius. The internal magnetic field is 100 times weaker than that of Earth and barely stands off the solar wind at the subsolar point to form the magnetosphere. (Image credit: NASA/APL/CIW)



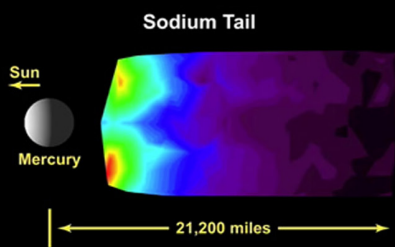
Magnetosphere

The global distribution of ionized sodium near Mercury, as measured by the Energetic Particle and Plasma Spectrometer (EPPS). Solar wind ion bombardment likely causes neutral atoms to be liberated from the surface, with sodium exhibiting distinct maxima near the magnetic cusps. (Image credit: Univ. of Michigan)



Surface Chemistry

Maps of Mercury's surface chemistry were created using data collected by the X-Ray Spectrometer (XRS), revealing Mercury's surface to have striking regions of chemical diversity, such as shown in the Mg/Si (left) and Al/Si (right) maps. (Image credit: NASA/APL/CIW)

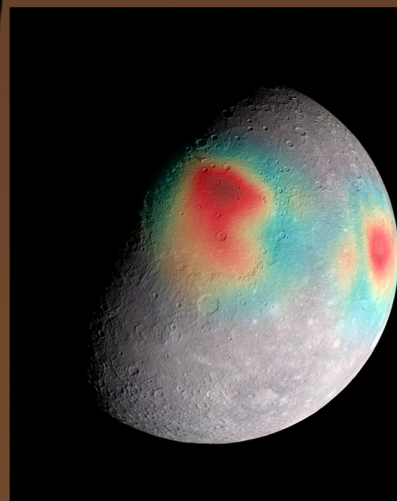


Exosphere

Through observations made by MESSENGER's Mercury Atmospheric and Surface Composition Spectrometer (MASCS), the science team was able to discern major chemical components of Mercury's tenuous and sparsely populated exosphere. (Image credit: NASA/Univ. of Colorado/APL/CIW)

Gravity

Analysis of radio tracking data has enabled derivation of maps of Mercury's gravity field. In this image, overlaid on a mosaic created using images taken by MESSENGER's MDIS instrument, red tones indicate mass concentrations—gravitational anomalies which are signatures of subsurface structure and evolution. (Image credit: NASA GSFC Science Visualization Studio/APL/CIW)





Mission Systems Engineer James Leary communicates on “the loop” (or “voicenet”) with mission operations, subsystem engineers, and the DSN.



Members of MESSENGER’s mission operations and engineering teams excitedly watch as launch operations in Cape Canaveral give the spacecraft its ride aboard a Delta II-Heavy launch vehicle to beyond Earth’s atmosphere and onto its cruise trajectory toward Mercury, 3 August 2004.



(Left to right) APL’s Space Department Head Mike Griffin, APL Director Rich Roca, Project Manager Dave Grant, and Space Department Engineering Branch Head Will Devereux on console at Kennedy Space Center for the launch of MESSENGER, 3 August 2004.



(Left to right) Ted Hartka, Will Devereux, and Dave Grant on the gantry to check out the launch vehicle at Kennedy Space Center.



(Left to right) Mark Holdridge, Karl Fielhauer, and Dipak Srinivasan discuss the observed Doppler shift—an initial indicator of a successful spacecraft maneuver—until the spacecraft can execute a command sequence to turn its X-band high-gain antenna toward Earth and transmit health and safety status in telemetry.



MESSENGER engineers, technicians, and quality assurance in one of APL’s cleanrooms, wrapping the spacecraft for transport. The copper-shaded material on the outside of the spacecraft is a blanket of multilayer insulation, a thermal insulator.



Ted Hartka oversees the loading of the MESSENGER spacecraft for transport to a Florida test facility and then on to Kennedy Space Center, where it will be launched.



A meeting of MESSENGER's flight software team following the successful first uplink of a software update to the spacecraft.



The team gathered in the Mission Operations Center (MOC) to celebrate the successful mission on the occasion of the spacecraft's final orbit (driven by command sequence 15113) and Mercury impact, 30 April 2015.



MESSENGER's mission operations team poses with a 1/5-scale model of the spacecraft.



(Left to right) Jim McAdams, Jack Ercol, and Carl Engelbrecht reference the spacecraft's planned trajectory.



Members of MESSENGER's mission operations team and engineering team follow the timeline of sequenced commands and, after a communications delay of one-way light time, watch telemetry points that verify successful execution of a maneuver.



(Left to right) Guidance and control engineers Dan O'Shaughnessy, Robin Vaughn, Gene Heyler, and Gabe Rogers analyze spacecraft telemetry.



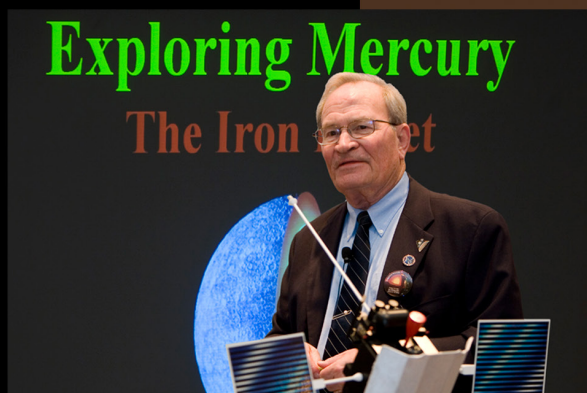
(Left to right) Brett Denevi, Larry Nittler, Sean Solomon, and Ralph McNutt at a press conference presenting exciting new Mercury results.



(Left to right) NASA Administrator Charles Boldin and Associate Administrator Ed Weiler congratulate APL Director Ralph Semmel and MESSENGER Mission Systems Engineer Eric Finnegan on the evening that MESSENGER became the first spacecraft to orbit the planet Mercury.



(Left to right) MESSENGER co-investigator and former APL Space Department Head Tom Krimigis and Adrian Hill, fault protection lead engineer, monitor telemetry to verify successful orbit insertion.



Bob Strom was a co-investigator on both U.S. Mercury missions, Mariner 10 and MESSENGER.



(Left to right) Project Manager Peter Bedini, Mission Systems Engineer Eric Finnegan, and Principal Investigator Sean Solomon monitoring the flyby trajectory.



Middle school students participating in Space Academy watch a demonstration in APL's environmental test facilities.



Principal Investigator Sean Solomon (center) celebrates the mission's success at the final meeting of the MESSENGER science team, with project managers from various phases of the mission (from left to right): Helene Winters, Max Peterson, Peter Bedini, and Dave Grant.



At a black-tie ceremony at the Air & Space Museum in Washington, DC, in 2014, Dan O'Shaughnessy becomes the first recipient of the Heinlein Award. His wife, Judy, and son, Owen, look on as Dan is recognized for being the first to employ the technique of solar sailing on a space mission.



Carly Ercol celebrates with her dad, Jack Ercol, MESSENGER thermal engineer, as he is awarded the 2008 Wright Brothers Medal for meritorious contribution to aeronautic engineering, in Toulouse, France.



On behalf of the MESSENGER team, Principal Investigator Sean Solomon (left) accepts NASA's Group Achievement Award from Jim Green, Director of NASA's Planetary Science Division, after successful execution of MESSENGER's first Mercury flyby in 2008.



U.S. Senator Barbara Mikulski visits APL in celebration of the Lab's 70th anniversary, and APL Director Ralph Semmel presents her with a framed reprint of the journal *Science*, with three MESSENGER papers, each telling a part of the story of water ice in Mercury's north-polar craters.